AN APPARATUS FOR ELICITING AND RECORDING THE PATELLAR TENDON REFLEX

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It is evident that if one is to study the patellar tendon reflex quantitatively it should be elicited by a stimulus of uniform intensity at regular intervals. Since this reflex is subject to variations due to very slight environmental changes it is desirable to have an apparatus which is capable of delivering stimuli automatically. With these ideas in view the apparatus described in this paper has been developed and thoroughly tested. The results obtained are so satisfactory that it seems desirable to give a rather detailed description of it.

The apparatus consists of four parts as follows: 1, the power unit; 2, the hammer unit; 3, the chair unit; 4, the recording unit.

The accompanying photograph shows the units assembled as they are used in carrying out the various experiments which have been performed.

The power unit. The first point to be considered in constructing the power unit is the frequency with which the stimuli are to be delivered. Before deciding upon an interval between stimuli best suited to the elicitation of the reflex, the time was observed which was necessary for the reflex to be completed. It was found that from 8 to 10 seconds were adequate for the completion of the reflex, allowing at the same time sufficient rest to obviate fatigue as a significant factor. Figure 2 is a working drawing of the power unit.

The desired frequency is secured by means of a system of pulleys together with resistance in the motor circuit. A 1750 R.P.M. constant speed motor, *A*, equipped with a steel pulley, *B*, is belted to a wood pulley, *C;* the shaft of the latter is fitted with a steel pulley, *D*, which is connected to a system of belt-driven reducing pulleys, *E*, *F*, *G*. In order to increase the range of speeds which can be obtained a parallel bank of lamps, *H*, is placed in series with the motor. (If desirable, a sliding resistance may be substituted for the lamp bank.) By varying the number of lamps in circuit the interval between stimuli can be made to vary from 4 to 12 seconds.

In order to change the circular to longitudinal motion an eccentric, *I*, is mounted upon the last pulley. An eccentric rod, *J*, is attached to a

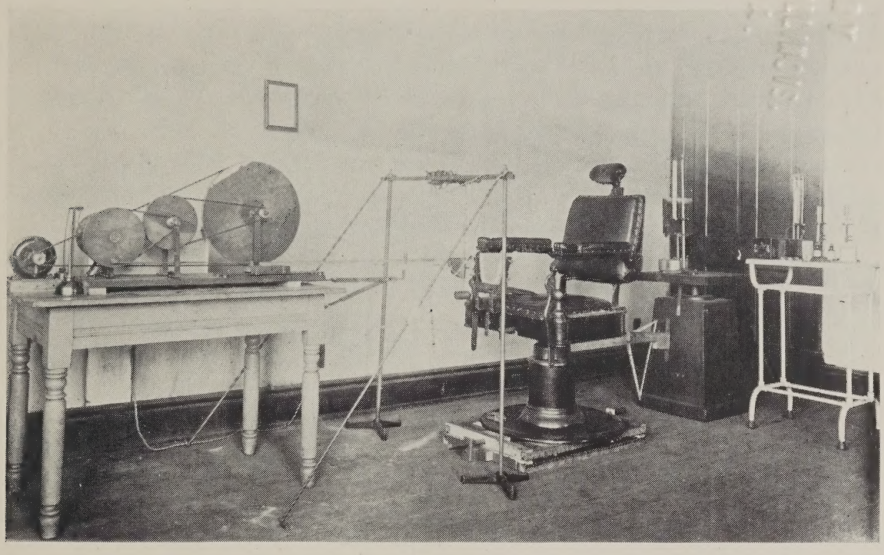

Fig. 1. An apparatus for eliciting and recording the patellar tendon reflex.

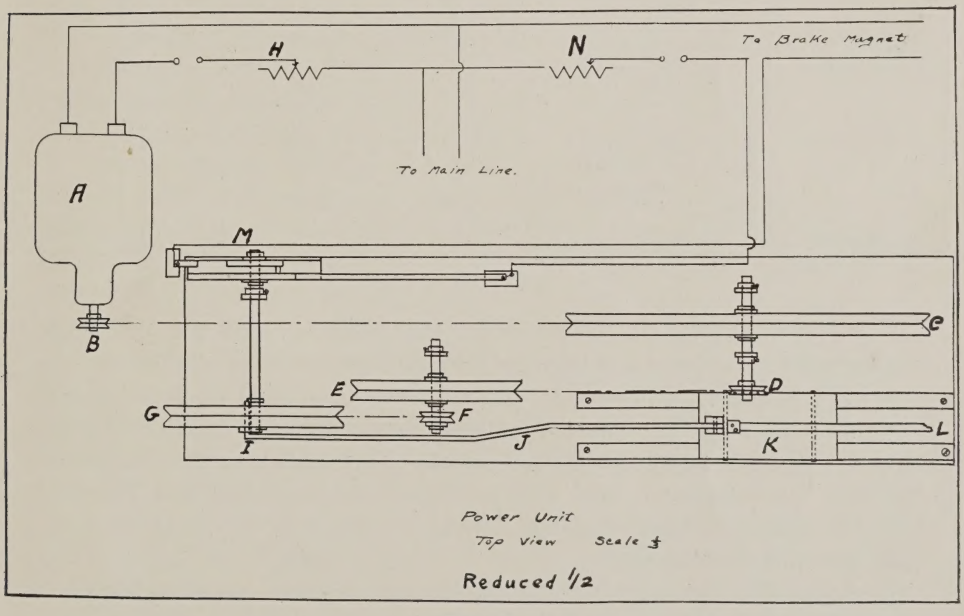

Fig. 2

carriage, K, which slides on a double track. It is held in place by a support at each end, running under the track.

A wood bar, L, is hinged to the upper surface of the carriage well toward the end to which the eccentric rod is attached. Upon the distal end of this bar a hook is attached for engaging a tripping device upon the hammer handle. The engaging bar is firmly supported by a deep grooved guide at the extremity of an iron bracket fastened to the end of a table. The power unit complete is mounted upon a small table.

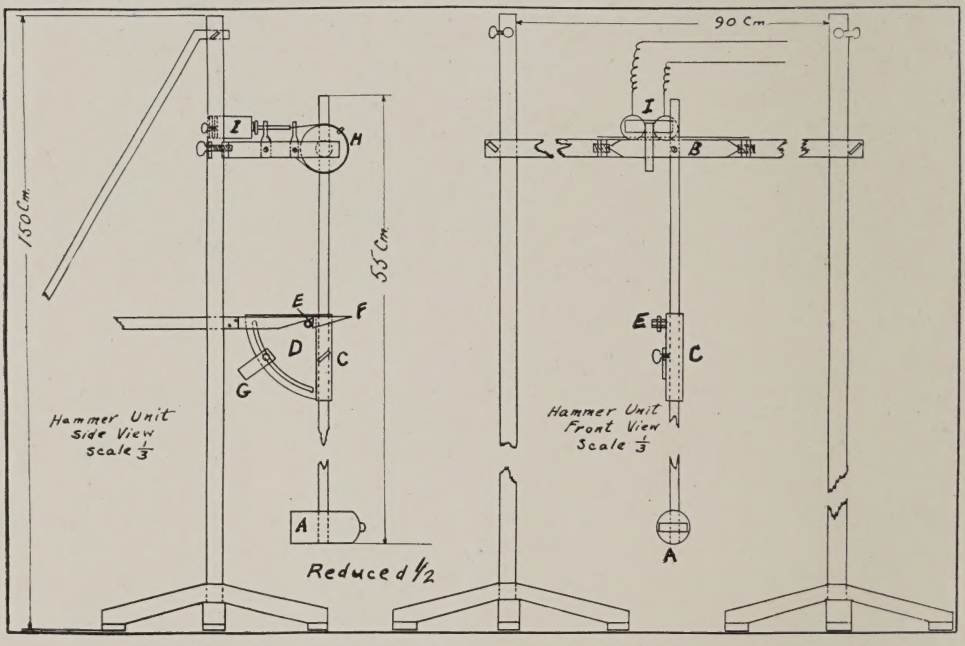

Fig. 3

The hammer unit. In constructing the hammer unit the principal points to be considered are adjustability and adequacy of striking force.

A steel hammer, A, weighing 824 grams is suspended upon a handle from an axle, B. The hammer handle passes through an axle, being securely held in place by a thumb screw. This arrangement makes the length of the hammer handle adjustable. The axle swings in a bracket provided with two brass bearings which are adjusted so as to offer as little resistance as possible.

In order that the hammer may swing automatically an engaging and tripping device is attached to the hammer handle. This device consists of a flattened metal sleeve, C, which is held in place upon the hammer handle by a thumb screw. To one side of the sleeve a brass quadrant, D, is fastened which presents a flat side parallel to the engaging hook.

Near the central angle of the quadrant a lug, *E*, with a freely moving brass sleeve is bolted perpendicular to the quadrant. This serves as an attachment for the engaging hook, *F*. A slot is cut in the quadrant near its circumference and parallel to it. Opposite the engaging hook a piece of metal the width of the hook, but somewhat shorter, is fastened to the arm. This serves as a guide so that when the hook engages the lug the quadrant passes between the guide on the one side and the hook on the other. A thumb screw passing through the sleeve to which the quadrant is fastened holds the engaging and tripping device firmly in position on the hammer handle. A metal strip, *G*, attached to the quadrant by means of a thumb screw serves as the tripping device. When the lug is engaged and the hammer pulled back the metal trip comes in contact with the inferior side of the hook arm, raising, and thus disengaging it, as the hammer continues to move toward the power unit. The hammer is then free to fall.

The power unit is placed at such a distance from the hammer unit that when the wood carriage reaches the distal extent of its excursion the hook on the hook arm drops over the lug on the quadrant. As it approaches the proximal end of its excursion the hammer is released and is free to fall against the patellar tendon.

It was found that when the hammer struck the tendon it rebounded, thus delivering a series of stimuli of diminishing force. This is objectionable since it not only serves as a source of annoyance but in case the subject is hyperirritable the first or second rebound may elicit the reflex. These secondary stimuli might obviously serve to augment or depress the desired reaction. In order to prevent this rebound an electrically controlled brake is mounted on the axle from which the hammer swings. A fiber drum, *H*, is forced tightly on the axle near its center; around the drum a band spring is placed. One end of the spring is securely fastened to a brace while the other end is attached to a soft iron bar which serves as an armature. The spring covers about two-thirds of the drum. Two electro-magnets, *I*, mounted upon a cross-bar behind the hammer draw the armature forward, thus tightening the spring and preventing a rebound of the hammer. The distance from the magnets to the armature is adjustable. In practice the adjustability of the magnets was found to be important.

The brake is needed an instant after the hammer strikes. This is determined by a timing device (*M*, fig. 2) attached to the axle of the eccentric pulley. The timing device consists of a wood pulley encircled by two brass strips, one of which completely encircles the pulley and through its connection with a copper brush serves as a constantly engaged terminal. The brush of the other terminal slides upon a second brass band partially encircling the pulley. The two bands are connected by

a metallic bridge. The gap in the second band is so placed as to give a break of the desired length and at the desired time, while the armature is passing over the dry wood of the pulley. The current is kept interrupted through most of the circuit by way of avoiding heating of the brake magnets. One-hundred-ten volts are used in all circuits. The strength of the magnets is controlled by a parallel bank of lamps (N, fig. 2) in series with the timer. A sliding resistance might be substituted for the lamp bank. The entire mechanism is suspended from a cross-bar firmly fastened to two uprights by thumb screws.

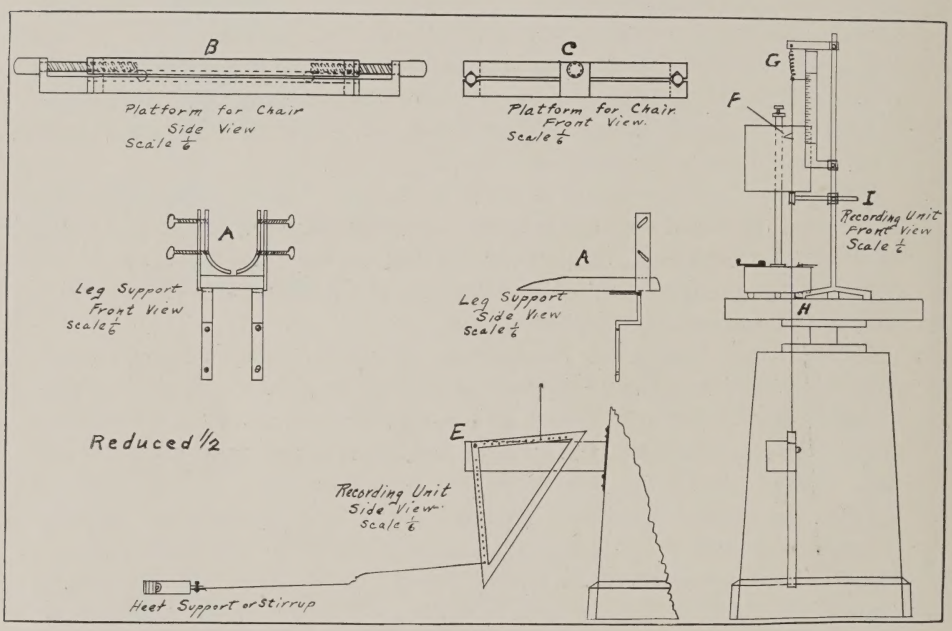

Fig. 4

The hammer unit includes three adjustments for varying the intensity of the blow: a, changing the length of the hammer handle; b, raising or lowering the engaging quadrant; c, adjusting the trip in the slot. The adjustability of the cross-bar from which the hammer swings makes it possible to compensate so that the height of the engaging arm remains constant.

The chair unit. The subject is seated in a barber's chair from which the foot-rest was removed. The necessary tension for the patellar tendon is secured by elevating the thigh somewhat above the horizontal and holding the leg slightly back of the vertical by its attachment to a spring that forms part of the recording device. The lower end of the thigh rests in a comfortable holder, at the distal end of which is a U-shaped

guide (*A*, fig. 4) so constructed that both the width of the U and the angles of its sides can be adjusted. Although this permits more or less forced lateral displacement of the leg, it is found in actual practice quite adequate to keep the point upon which the hammer impinges in a constant position.

The chair unaltered furnishes up, down and lateral adjustments. To permit forward and backward adjustments the chair unit is mounted upon a double base (*B* and *C*, fig. 4), between which are four steel balls running in an iron groove. Wood screws in front and behind maintain the adjustment.

The recording unit. A stirrup, *D*, is attached by a set screw to the heel of the subject's shoe. From the stirrup runs a wire to the vertical arm of a triangular device, *E*, suspended at its right angle. To the horizontal arm of the triangle a second piece of piano wire is attached which runs to a stylus, *F*, suspended from a wire spring, *G*. The triangle pro-

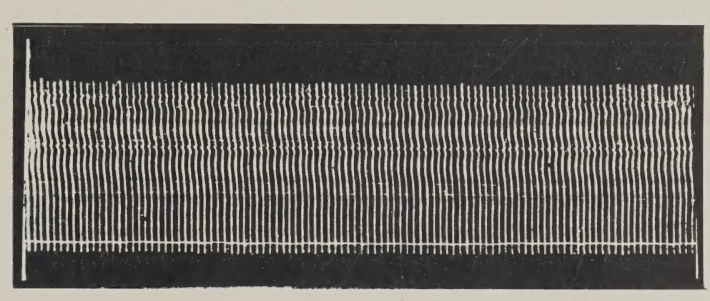

Fig. 5. A record showing the constancy of the intensity of the stroke and the regularity with which the hammer falls.

vides a means of changing the relation of the excursion of the heel to the excursion of the stylus. In practice it has been found desirable to work with relatively low kicks to permit registering the marked augmentations frequently encountered.

The stylus spring plays an important rôle in bringing the heel back after each excursion exactly to its original position. By changing the tension on the spring the resistance offered to the reflex may be varied.

The wire from the horizontal arm of the triangle passes through a screw eye at *H* (not shown in drawing) and under a pulley, *I*. The pulley serves as a guide so that the stylus writes perpendicularly on the drum. A stop is clamped on the wire just below the screw eye to prevent fling. This device serves also to keep the initial tension constant.

Time markers and signal magnets may be added as occasion demands. The entire unit is mounted on a heavy pedestal.

Constancy of intervals and force of strokes. The constancy of the intensity and the regularity of the strokes are illustrated by figure 5. This record was made by allowing the hammer to fall against a lever hinged to the floor to take the place of the leg of a subject. Resistance was supplied by a rubber band.

The records read from right to left due to the fact that the base line is at the top of the record. This method was adopted to avoid the use of a second pulley.

Experience with this apparatus has shown that it is capable of eliciting the patellar tendon reflex to a nicety and of accurately recording any changes which are exhibited by it. Its complete automaticity, permitting the elimination of certain extraneous environmental variables is a valuable feature. Its sturdiness of construction and delicacy of performance render it a valuable addition to class room armamentarium both in physiology and pharmacology.

It is a pleasure to express my appreciation for various suggestions received from Professors A. P. Weiss and R. G. Hoskins. I also wish to thank Mr. George Woodward and Mr. Carl Effler for their suggestions and assistance throughout the construction of this apparatus.